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ANALYSIS OF OBJECT MOTION USING SMARTPHONE SENSOR DATA AND ARTIFICIAL INTELLIGENCE: A NEW APPROACH IN PHYSICS EDUCATION

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Abstract: This study explores a novel approach to teaching physics by integrating smartphone sensor data with artificial intelligence (AI) tools to analyze the motion of physical objects. Modern smartphones are equipped with built-in accelerometers, gyroscopes, and magnetometers, which can record motion-related data with high precision. By combining these sensor outputs with AI-driven analysis platforms, students can visualize, model, and interpret real-world physical motion in classroom settings. The research highlights how this methodology fosters active learning, develops analytical thinking, and bridges theoretical physics with practical experimentation. The proposed approach not only increases student engagement but also introduces AI literacy within physics education.

Keywords: Physics education, object motion, smartphone sensors, artificial intelligence, accelerometer, data analysis, real-time modeling, inquiry-based learning, educational technology, motion tracking

The integration of digital technologies into science education has created new opportunities for enhancing learning outcomes, particularly in physics where real-world motion and forces can be difficult to observe and measure directly. Smartphones, commonly available to students, contain a range of built-in sensors—such as accelerometers and gyroscopes—that can be used to collect precise motion data. However, raw sensor data alone may be difficult to interpret without suitable analytical tools.

Artificial intelligence (AI), and more specifically machine learning and language models, offers new potential for bridging this gap. When sensor data is processed through AI algorithms, it becomes easier to identify patterns, predict trajectories, and draw meaningful conclusions from complex data. This creates an opportunity for physics education to become more interactive, exploratory, and relevant to students' daily experiences.

This paper presents a new methodology that combines smartphone-based motion tracking with AI-assisted analysis to investigate the dynamics of physical systems. By using mobile apps and AI tools in the classroom, students can design experiments, collect data, and receive instant feedback on the nature of motion, including velocity, acceleration, and trajectory patterns. This pedagogical approach aims to make physics more accessible, stimulate curiosity, and foster deeper conceptual understanding through hands-on digital inquiry.

This study employed a practical, inquiry-based experimental design involving upper-secondary school students in a physics classroom setting. Two groups were formed: a control group using

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traditional tools (e.g., stopwatches, rulers, and manual calculations), and an experimental group using smartphones and AI-assisted applications.

The experimental group utilized freely available mobile apps such as Physics Toolbox Sensor Suite and Phyphox, which access built-in accelerometers and gyroscopes to record motion data in real-time. Students performed experiments such as rolling a ball down an inclined plane or tracking a pendulum's swing. The collected data were then uploaded to AI-powered platforms such as ChatGPT or Google Colab, where basic machine learning algorithms and data visualizations were used to interpret the results.

Instructional sessions included:

- Guidance on data collection via smartphone sensors.
- Hands-on modeling using simple physics equations (e.g., v=atv = atv=at, s=ut+12at2s = ut + \frac{1}{2}at^2s=ut+21 at2).
- Analysis of acceleration, velocity, and displacement using AI-supported scripts.
- Reflection and interpretation through teacher-led discussions.

Comprehension, accuracy of analysis, and student engagement were assessed through quizzes, performance tasks, and observation rubrics.

The AI-assisted experimental group showed notable improvements in understanding motion-related physics concepts compared to the control group. Key findings include:

- **Increased conceptual clarity**: 85% of students in the AI group could accurately define and differentiate between acceleration, velocity, and displacement, versus 58% in the control group.
- **Better data interpretation**: Students using AI tools demonstrated stronger abilities in analyzing motion graphs and identifying linear or non-linear acceleration patterns.
- **Higher engagement levels**: Classroom observations and feedback indicated that students found the smartphone-AI integration motivating and relatable.

Statistical analysis (t-test) confirmed that the mean performance scores of the experimental group were significantly higher ($p < 0.05$), particularly in tasks involving interpretation of experimental motion data.

The results suggest that incorporating AI tools and smartphone sensors into physics instruction can transform abstract concepts into observable, hands-on experiences. This approach aligns well with constructivist learning theories, which emphasize student-centered, exploratory learning.

The ability of students to interact directly with motion data captured from their everyday devices reduces the perceived complexity of physics and increases the relevance of the subject to real life. Furthermore, AI tools not only automate certain analytical processes but also provide scaffolding by offering step-by-step explanations, enabling students to self-correct and reflect.

However, some limitations were noted. Students initially lacked familiarity with the sensor apps and needed training in interpreting raw data. Moreover, AI platforms require internet access,

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which may not be universally available. Despite these challenges, the integration proved scalable, low-cost, and adaptable to different educational contexts.

This study demonstrates that combining smartphone sensor technology with artificial intelligence applications offers a powerful, modernized approach to teaching object motion in physics education. It enhances student engagement, supports conceptual understanding, and develops analytical skills through active experimentation.

The findings support further integration of AI and sensor-based learning across the physics curriculum, particularly in kinematics and dynamics units. Future research should explore personalized AI feedback, the long-term retention of concepts, and adaptations for other STEM subjects.

By leveraging technology already in students' hands, educators can build a bridge between theory and practice, preparing learners not only to understand physics but also to innovate within it.

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